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DEPENDENCE OF THE OPTICAL CONTINUOUS SPECTRUM OF QUASARS ON THEIR RED SHIFT

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SUMMARY

The determination of the dependence of the optical continuous spectrum of QSS on their red-shift is based on data of the three-color photometry (UBV). It is first established for QSS with known red-shifts, revealing an absorption "step" in QSS spectra. Preliminary estimates of red-shifts are then made for some of the unidentified QSS. However, it is not yet clear what matter is responsible for absorption in intergalactic medium.

For further corroboration of the conclusions the authors recommend new identifications of quasars and their m-c-photometry, concentrating the research in the region (2250 ± 150) Å for direct detection of the absorption "step".

* • *

We utilized for the characteristic of the optical spectrum's form the data of the three-color photometry (U B V system) of quasistellar sources (QSS) [1, 2]. For the qualitative estimate we introduced the value of the "curvature" $\Delta = \alpha_1 - \alpha_2$, where α_1 is the spectral index in UB and α_2 is the spectral index in BV [3].

The spectrum is represented in the form $F_\nu \sim \nu^{-\alpha}$. For the α interval from 0 to 2, we have:

$$\bar{\lambda}_U = (3598 \pm 12)\,\text{Å}, \quad \bar{\lambda}_B = (4412 \pm 28)\,\text{Å}, \quad \bar{\lambda}_V = (5525 \pm 22)\,\text{Å}.$$

If there is no break in the spectrum of the source, we have

$$\alpha_1 = \alpha_2 \quad \text{and} \quad \Delta = 0.$$

For QSS with known red-shifts <u>z</u> and UBV we plotted the dependence of Δ on z (Fig. 1, solid curve).

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* ZAVISIMOST' OPTICHESKOGO NEPRERYVNOGO SPEKTRA KVAZAROV OT IKH KRASNOGO SMESHCHENIYA.

Taking into account that, as z increases, various portions of the spectrum pass through the UBV filters, it may be expected that the dependence $\Delta(z)$ reflects some general property of QSS spectra. Since the geometrical sense of the spectral index

$$\alpha = \frac{\partial \log F_\nu}{\partial \log \nu}$$

is the first derivative, while the curvature(s)

$$\Delta \sim \frac{\partial^2 \log F_\nu}{(\partial \log \nu)^2}$$

is the second derivative, it apparently follows from Fig. 1 that there is an "absorption step" in QSS spectra. Indeed, we have for a stepped spectrum

$$F_\nu = kA\nu^{-\alpha},$$

where

$$k = \begin{cases} 1, & \lambda > \lambda_0 \ (1 + z) \\ k^* < 1, & \lambda < \lambda_0 \ (1 + z) \end{cases}$$

the first and the second derivatives have a form represented in Fig. 2.

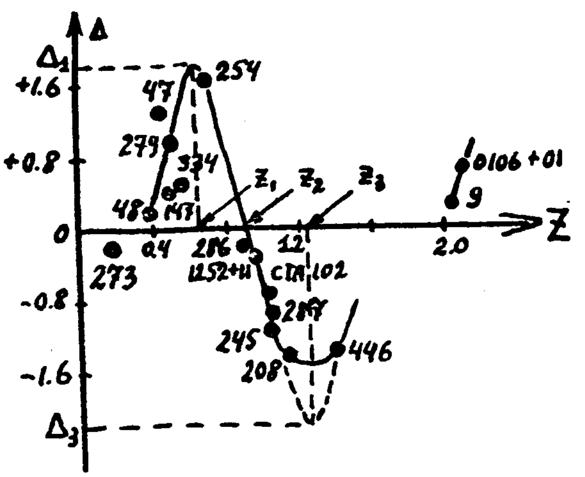

Fig. 1

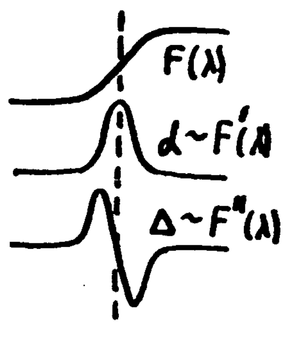

Fig. 2

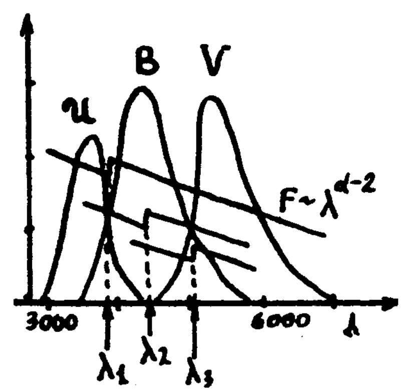

Fig. 3

As to the method of finding λ_0, it is clear from Fig. 3. For a source with such a z_1 that $\lambda_1 = \lambda_0 \ (1 + z_1) \approx 3860$ Å, we shall have $\Delta = \Delta_1 = \max \Delta$. For a source with such $z = z_2$, that $\lambda_2 = \lambda_0 \ (1 + z) \approx 4380$ Å, we have $\Delta = 0$.

For a source with such a z_3 that $\lambda_3 = \lambda_0 (1 + z_3) \approx 5050 \mathring{A}$, $\Delta = \Delta_3 = \min \Delta$. From the graph of Fig. 1 we find

$$z_1 \approx 0.7; \quad z_2 \approx 0.9; \quad z_3 \approx 1.25.$$

Hence

$$\bar{\lambda}_0 = (2250 \pm 150)\,\mathring{A}.$$

In order to determine the depth of the "step" we shall make use of the formulas of [3]. After transformations we shall obtain the relation between the quantities Δ_i and k_i $(i = 1.3)$,

$$\Delta_{1,3} \approx - 10.63 \log k_{1,3} \qquad (1)$$

For $\Delta_1 \approx 1.8$ we obtain $k_1 \approx 0.68$.

One may wonder where the absorption "step" in the spectrum of all QSS may appear from?.- There are two possibilities :

1) there is near the emission source a substance with a wide absorption band, beginning at about 2250 Å;

2) The substance (matter), responsible for absorption is dispersed in the intergalactic space.

What matter in the intergalactic medium or in the medium surrounding the QSS, is responsible for the absorption ? No unilateral response to this question can yet be given. Let us note only, that in [4] there is an indication of the existence of anomalous absorption by interstellar dust with maximum near 2300 Å. The observed absorption agrees well with the graphitic dust particle model [5].

In the model of an evolving Universe and on the condition of curtailing the number of absorbing particles in a unit of attending volume, the optical thickness is

$$r = r_0 \frac{(1 + z)^2}{\sqrt{1 + 2 q_0 z}} ,$$

where $r_0 = n_0 k(\lambda) l$, n_0 is the density of particles at the present time, $k(\lambda)$ is the absorption coefficient, q_0 is the time-lag parameter.
At $q_0 = ½ \,(\rho = \rho_{KP_0})$

$$\Delta_i \sim (1 + z)^{3/2}$$

According to the experimental points in the graph of Fig. 1 (solid curve) no amplitude dependence of Δ on z is seen. Apparently, the fact of the matter is that the amplitude of negative Δ (Δ_3 in Fig. 1) must be attained for sources with $z = 1.1 \rightarrow 1.4$, while in this interval of z no sources have yet been detected. It is true, however, that among the unidentified QSS (and there are more than 30 of them) with known z, there is the source 3C-204, for which $\Delta_3 = -2.25$. If the observations give for it values of z within the range $1.1 - 1.4$, this will serve as a confirmation of the dependence of the amplitude of Δ on z (in Fig. 1 it is plotted by dashes).

Evidently, for final conclusions a broader material is required in regard to the identification and photometry of quasistellar objects. This will allow to emphasize more reliably the dependence of Δ on z, on the basis of which estimates of z could be made even for unidentified sources, if UBV are measured for them. The possibility of estimating z unambiguously increases for sources with $U - B$ and $B - V$, corresponding to Δ close to Δ_1 or to Δ_3. (In this case the errors for z will not exceed 0.1). Even according to the graph $\Delta(z)$ brought out, which was plotted by the available experimental material, preliminary estimates of z can be made for some of the unidentified quasars (see Table 1).

TABLE 1

QSS	Δ	The z forecast
3C-138	+1.83	0.7 ± 0.2
3C-275.1	+1.63	0.5 ÷ 0.8
3C-280.1	+1.83	0.7 ± 0.2
3C-268.2	+1.8	0.7 ± 0.2
3C-277.1	+1.58	0.5 ÷ 0.8
3C-181	-1.88	1.1 ÷ 1.4
3C-204	-2.25	1.25 ± 0.2

For future estimates of the time-lag parameter, more precise values of the dependence $\Delta(z)$ may be used. Indeed

$$q_0 = \frac{1}{2} \frac{\Delta_3^2 (1+z_1)^4 - \Delta_1^2 (1+z_3)^4}{\Delta_1^2 (1+z_3)^4 z_1 - \Delta_3^2 (1+z_1)^4 z_3} .$$

For sources with $z > 2$ there must be observed a dependence $\Delta(z)$ on account of absorption by intergalactic hydrogen [6, 7]. Qualitatively it must repeat the dependence $\Delta(z)$ for nearer sources.

In conclusion we shall stress once more the necessity of further checking the conclusions obtained. Required to that effect are :

1) new identifications of quasars and their multi-color photometry;

2) conducting careful photometric investigations of quasar spectra in the region $\lambda_0 = (2250 \pm 150)$ Å for direct direct detection of the absorption "step".

**** THE END ****

GAISH

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